

## **Optimization of Hybrid PV/Wind System for Remote Telecom Station, a Case Study of Different Sites in Algeria**

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**Abstract.** In this work, we would supply the remote telecom station by the renewable energy only sources for two reasons. First one for reducing the greenhouse gas (GHG) emissions and climate change for conserving our planet and our life. In the Second things the remote telecom station is so far from the grid network of electricity, therefore the cost of supply the grid connected is very expensive. So we use hybrid renewable system because it's clean and decentralized that mean available everywhere. It's the perfect solution of combination between two resources of energy to ensure supply the telecom station. We using HOMER software for simulation the hybrid system and find the optimum sizing; HOMER has been developed by United States (US) National Renewable Energy Laboratory (NREL).

We choose the hybrid PV/Wind energy and use a battery bank to find the margin of safety which corresponds to a desired reliability with minimal cost for the different sites in Algeria. We find a profitable results of hybrid system PV/Wind per unit (kWh) the cost of energy (COE) are 0.417, 0.371, 0.325 and 0.285 US\$/KWh respectively for the sites Algiers, Constantine, Ghardaia and Adrar.

**Keywords:** optimization, hybrid system, remote telecom station, different sites in Algeria.

### **1. Introduction**

Telecommunication networks have changed the way people live, work and think. Many people in the worldwide are connected by telecommunication networks, in a remote area the grid electricity is not available because it's so far and high cost for connected by the grid networks, thus the actual used diesel generator without battery bank for alimentation the base of the telecom station [1]; but this source of energy emission a green house gas (GHG), although the growing of demand of power and the increasing awareness of the dangers of global earth warming , though renewable energy is the best solution to get ours supply, this sources available in irregular quantity over time, that are not suffice in all locations and that want high capital costs. The initial cost of renewable energy systems is much higher than a fossil-fuel system [2]. Autonomous wind plus solar power systems is among the most important and environmentally-friendly, locally available and they are free. It's among effective solutions for supply the electrification of remote consumers. A feasible solution is to combine those different renewable energy sources form a hybrid energy system like micro-grid. When solar and wind energy is alternative resources we using the hybridization between them with battery of storage for assured to stay all time supply with energy. Such hybrid system gives more reliability and may be cost effective [3], [4].

### **2. Geographical Location**

The weather data they are available in NASA (the National Aeronautics and Space Administration) sponsored climate data information website OPENEI (Open Energy Information) [5]. Put in Table 1 the

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parameters like latitude, longitude and altitude of different zone in Algeria that presented one city each region of coastal, high plateaus and desert (Sahara) zone.

Table 1: geographical data for selected station

Site	Latitude	Longitude	Altitude (m above sea level)	Topographic Situation
Algiers	36 °40' N	3 °13' E	29	Coastal zone
Constantine	36 °16' N	6 °37' E	694	High plateaus
Ghardaia	32 °23' N	3 °48' E	469	Sahara
Adrar	27 °53' N	0 °11' W	283	

### 3. Solar and Wind Potential of the Site

When put the latitude, longitude and time zone of a specific location that will be get the data of monthly average solar radiation, a clearness index and average wind speed by using NASA.

#### 3.1. Solar resource data

For the homer software doing the simulation we must to put the average global solar radiation on the horizontal surface in kWh/m<sup>2</sup>, for each hour of the year (Fig. 1).

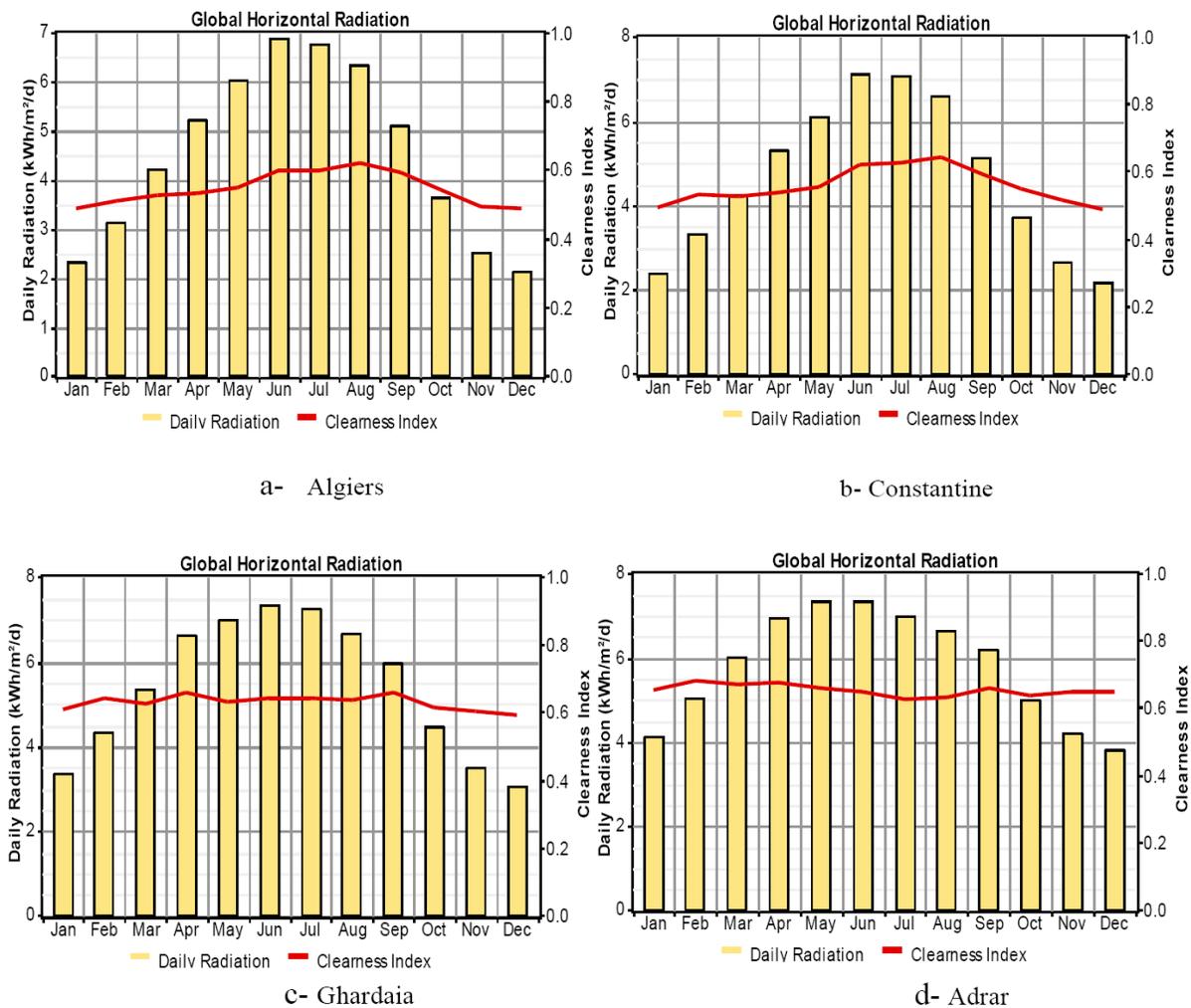


Fig. 1. Average daily solar radiation and clearness index

#### 3.2. Wind resource data

The Average monthly wind speed in one year is depicted in Fig. 2, for the average wind speed, for each hour of the year; you must add others parameters such as the specified seasonal and daily patterns, in addition to the specified Weibull distribution and autocorrelation factor.

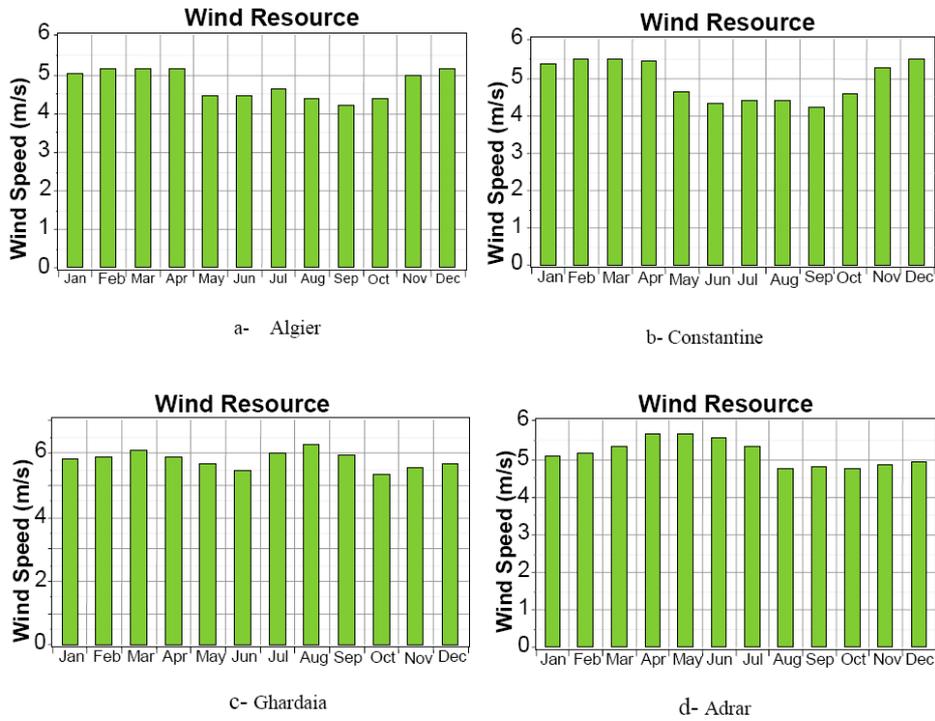


Fig. 2. Average wind speed in a year

#### 4. Load Data

The power consumption of the telecommunication base station is division for two parts a full load power and a half power load is shown in Fig. 3.

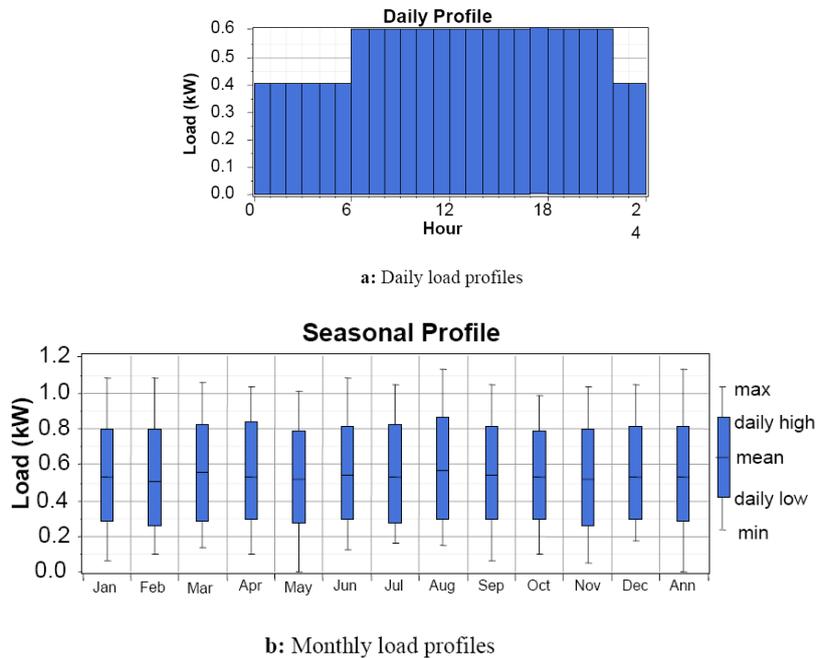


Fig. 3. Daily and Monthly load during a year

The telecom station model is CDMA 2C10 BTS is consumption 13 KWh per day and the peak power is 1.1 kW [1], it's supplied by the direct current bus without using converter component for economic cause.

#### 5. HOMER Simulation Software

HOMER (Hybrid Optimization Model for Electric Renewable) developed by the National Renewable Energy Laboratory NREL; HOMER design the both stand alone and grid connected such as micro-power

system of renewable energies like photovoltaic modules, wind turbines, biomass, hydro, fossil and fuel cells, hydrogen storage and batteries for thermal and electric load. It's doing the simulation of hybrid system, optimization that means find the least cost solution and sensitivity Analysis. Its can compare between the systems in the economic side; in Fig. 4 shown the architecture of HOMER software [6].

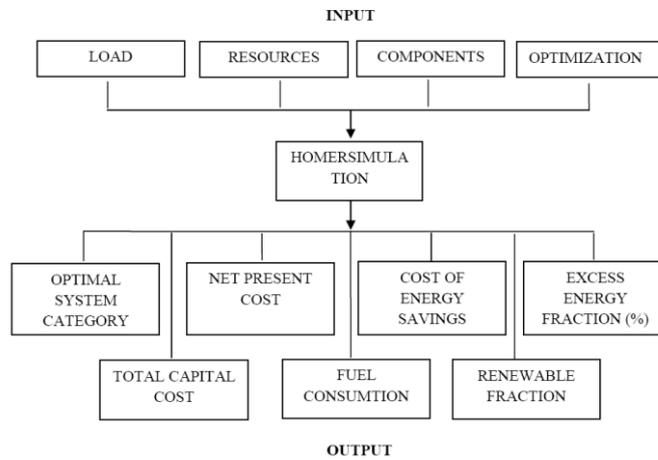


Fig. 4. Architecture of HOMER software [7]

HOMER simulates 8,760 hours in a year and gets a possible system configurations; HOMER presents a list of feasible systems, classified by the optimal Net Present Cost (NPC).

In the Architecture of HOMER software that contains the input that must to put it such as a load, component types capital, replacement, operation and maintenance costs, and the results of net present cost and total cost, cost of energy, excess energy fraction and optimal system category.

## 6. Proposed Model

We use HOMER software for simulating and find the optimum size of the hybrid system between Photovoltaic and Wind energy using the Battery bank for insures the shortage of systems.

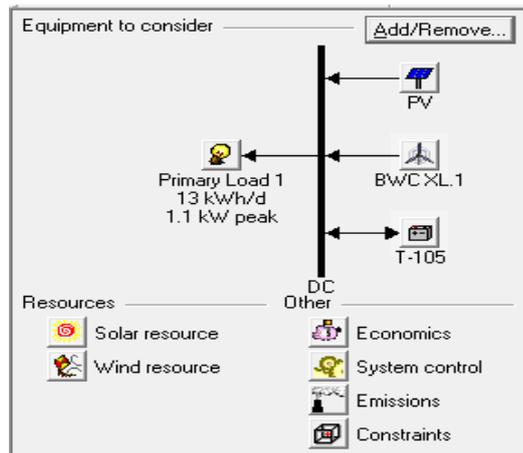


Fig. 5. Schematic diagram of hybrid system

The component uses in the system are PV array, wind turbine, battery and direct current DC bus of telecommunication load, so don't necessary to put the converter like shown in Fig. 5.

For choose an optimal solution we take on consideration the following factor: the out power and the price; in fact we do the simulation for a different wind turbine that produce a direct current and a power of 1 KW like BWC XL.1 and SW Whisper 200 and a wind turbine SW Whisper 500 that produce a 3 KW of power by a direct power. And for the batteries we do the simulation of three models of batteries like a Trojan T-105 of a Nominal capacity 225 Ah (1.35 KWh) with a nominal voltage 6V and Trojan L16P with a

nominal capacity 360 Ah (2.16KWh) with nominal voltage 6V and Surette S460 with Nominal capacity 460 Ah (2.76 KWh); nominal voltage 6V. We choose the components for find the optimal result: the photovoltaic panels that produce the power of 280 W of SolarWorld 280 Silver Mono Plus by 365 \$ for each panel, TrojanT-105 and BWC XL.

## 7. Result and Discussion

HOMER software performs several simulations in order to obtain the optimal sizing of the hybrid System between the follow components: photovoltaic array, wind turbine and batteries bank for stand-alone of telecom base station.

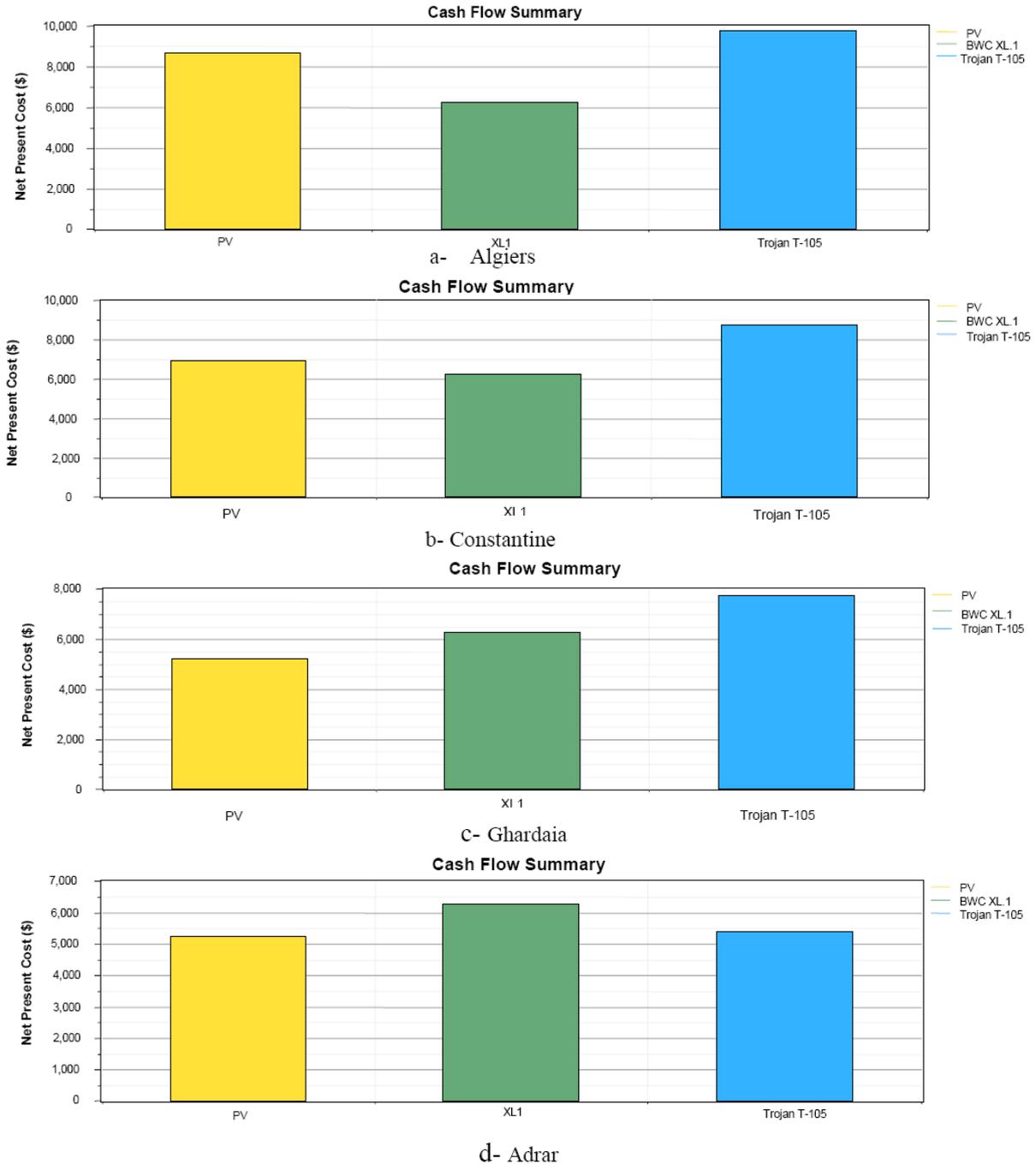


Fig. 6. Cost for component of standalone PV-wind system

The optimal combination of two resources of renewable energy solar and wind system, we find in case studies the following components: In the Coastal zone a specific in Algiers we find 5 KW of PV Array and 1 KW of wind turbine and 29 of batteries with capacity of 225 Ah and get the net present cost is 24,722 dollar US. So the cost of energy of one kilowatt-hour is 0,417 US\$/KWh as shown in Fig. 6.

In the site of Constantine that belong in the high plateaus we find that decrease of the components use comparison by Algiers site for the reason that it's a higher solar resource, contain a 4 KW of PV Array and 1 KW of wind turbine and 26 batteries with capacity of 225 Ah and get the net present cost is 22,982 US\$. As a result the cost of energy of one kilowatt-hour is 0.371 US\$/KWh.

In Sahara region is the higher solar resource and its own the high wind speed in Adrar. In the sites of Ghardaia and Adrar we show the results of are the PV/Wind hybrid system is not optimal sizing but it satisfactory result because it not high very cost and ensures the diversity of resource. The hybrid system in this case show in Ghardaia the follow sizing 3 kW of PV Array and 1 kW of wind turbine and 23 of batteries with capacity of 225 Ah and get the net present cost is 19,241 US\$. Thus the cost of energy of one kilowatt-hour is 0.325 US\$/kWh and the optimal sizing in Adrar is 3 KW of PV Array and 1 kW of wind turbine and 16 of batteries with capacity of 225 Ah and get the net present cost is 16,884 US\$. Therefore the cost of energy of one kilowatt-hour is 0.285 US\$/kWh.

In all sites we show that the main resource is solar energy; thus the Coastal zone and high plateaus illustrate the fraction limit of solar resource between (72 -78%) and the wind resource between (22-28%). In Sahara zone increase the solar radiation, hour of sun shine and wind speed therefore augment the power; hence decrease the size of components: PV Array and batteries but the wind turbine amplifies his energy produce that means decrease the capital cost of system is depicted in Fig. 7.

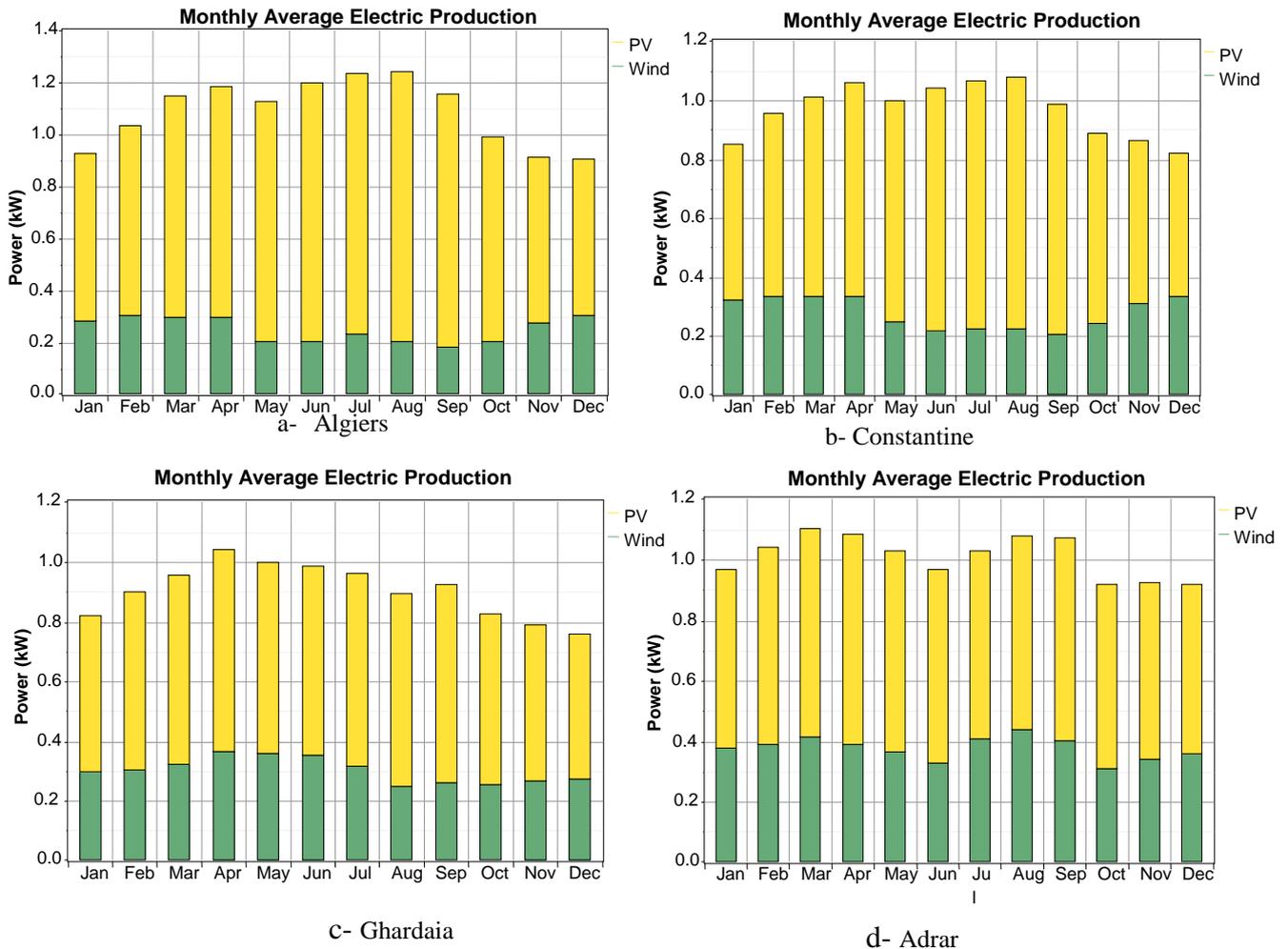


Fig. 7. Monthly power production from different sources in PV-wind system

In the Table 2 we cited the summary of the optimal components using and the total cost each site.

The load consumption of telecom base station in a long of one year is 4,632 KWh/year and the hybrid system produced 9,538; 8,463; 7,903; and 8,843 KWh/year respectively for the sites Algiers, Constantine, Ghardaia, and Adrar.

Table 2: the results of Net Present Cost (NPC) and Cost of Energy (COE) for different sites in Algeria

Site	PV (KW)	Wind turbine	Battery T-105	Initial capital	Operating cost (\$/yr)	Total NPC	COE (\$/KWh)
Algiers	5	1	29	17518 \$	564	25722 \$	0,417
Constantine	4	1	26	15419 \$	513	21982 \$	0,371
Ghardaia	3	1	23	13321 \$	464	19241 \$	0,325
Adrar	3	1	16	11977 \$	384	16884 \$	0,285

## 8. Conclusion

In this study, our search for a technically feasible and economically viable of hybrid solution for off-grid electricity to supply a remote telecommunication base station for different zone of Algeria. We use in proposing a hybrid system of two renewable energies, solar and wind for the reason that the potential of solar and wind in Algeria is not little. The optimized hybrid PV/Wind/Battery system gets a best solution and the optimal net present cost (NPC) and cost of energy (COE) in each site that studied. The results that find are excellent comparative by the high cost of grid connected for relating a far sites and existing system that supply by diesel energy. On the others side you must get on consideration this hybrid system is as clean and renewable energy that mean not air pollution and CO<sub>2</sub> emission.

## 9. References

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